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Comments on *Draft U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2017*

Environmental Defense Fund (EDF) and Clean Air Task Force (CATF) appreciate the opportunity to provide comments on EPA's *Draft U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2017* (2019 GHGI). In our comments, we discuss a recently published, peer-reviewed paper that estimates 2015 U.S. Petroleum and Natural Gas Systems emissions, and suggest similar approaches that could be used by EPA to more accurately estimate emissions by incorporating facility-level and basin-level data into the GHGI.

Additionally, we support EPA's decision to continue to use empirical, site-level data from Marchese et al (2015) to estimate methane emissions from gathering and boosting stations. Emissions would have been greatly underestimated if EPA changed to the proposed approach based on EPA Greenhouse Gas Reporting Program (GHGRP) emissions data. For future considerations of updates to this source, we suggest that EPA consults our stakeholder feedback on the 2018 GHGI memos, in which we describe an alternative method that uses data from both GHGRP and Marchese et al to most accurately estimate total emissions with a best approximation of source-specific emissions.

1. The current GHGI underestimates Petroleum and Natural Gas Systems methane emissions

A recently published paper in *Science*, Alvarez et al (2018), synthesized data from several recent studies to estimate 2015 U.S. oil and gas (O&G) supply chain methane (CH_4) emissions of 13±2 teragrams (Tg) CH_4, approximately 60% higher than the estimate for Petroleum and Natural Gas Systems for 2015 in the 2017 EPA GHGI. The O&G production segment is the largest source of this difference (7.6 vs 3.5 Tg) with three other segments also having higher emission estimates than the GHGI: gathering (2.6 vs 2.3 Tg), processing (0.72 vs 0.44 Tg), and transmission and storage (1.8 vs 1.4 Tg).

Alvarez et al (2018) used facility-level measurements as the primary data source for estimating emissions, including data from over 400 well pads in six basins collected with ground-based, mobile approaches such as EPA Other Test Method 33A (OTM 33A). Site-based emission estimates were validated with top-down, basin-level data derived from aerial mass balance estimates in nine basins. The paper also developed an alternative emission inventory using a component-level approach analogous to the GHGI for the production segment with updates to specific source categories. For example, pneumatic controller emissions were estimated with a combination of

GHGRP activity data and custom emission factors (EFs) based on Allen et al (2014). The full description of the alternative inventory methods can be found in Alvarez et al supplementary materials section S1.4. The alternative inventory resulted in an emission estimate of 8.8 Tg CH_4 for Petroleum and Natural Gas Systems, substantially lower than the primary estimate based on site-level data and validated with basin-level data.

Both the Alvarez et al alternative inventory and GHGI are thought to underestimate emissions due to limitations of the component-level approach. The positively skewed distribution of O&G component emission rates makes it likely that EFs based on the arithmetic mean of limited measurements will underestimate the mean emission rate of the full population. Additionally, site-level estimates based on the aggregate of component-level measurements tend to be biased low because some emissions sources may be overlooked, misquantified, or unsafe to measure. As described in Alvarez et al (2018),

> *Consequently, the most likely hypothesis for the difference between the EPA GHGI and BU [bottom-up] estimates derived from facility-level measurements is that measurements used to develop GHGI emission factors under-sample abnormal operating conditions encountered during the BU work. Component-based inventory estimates like the GHGI have been shown to underestimate facility-level emissions, probably because of the technical difficulty and safety and liability risks associated with measuring large emissions from, for example, venting tanks such as those observed in aerial surveys.*

For each segment, we discuss specific examples of how the GHGI underestimates emissions.

For the production segment, a previous study based on Barnett Shale data, Zavala-Araiza et al (2017), compared facility-level estimates derived from site-based measurements and aggregate, component-based estimates. Site-based estimates were 50% higher than component-based estimates, with the largest discrepancy found in the highest emitting sources. This gap was attributed primarily to abnormal process conditions that cause high emission rates, such as separator malfunctions that lead to irregular storage tank emissions. This hypothesis is supported by Lyon et al (2016), which used aerial infrared camera surveys of over 8,000 well pads in 7 basins to identify high emitters: tanks accounted for over 90% of these sources, and in several basins, occurred at a greater frequency than expected from normal emissions like tank flashing; in contrast, no large emissions were identified from sources like pneumatic controllers or connector leaks. Therefore, it is likely that much of the GHGI underestimate is attributable to missing, large sources that are difficult to observe, categorize, and quantify.

For the gathering and boosting (G&B) segment, which the GHGI classifies as a sub-category within the Natural Gas Systems production segment, EPA currently estimates G&B station emissions with facility-level emission factors from Marchese et al (2015). That study estimated 2012 U.S. G&B station emissions were 1,697 (+189/−185) Gg CH_4 based on site-level measurements at 114 stations published in Mitchell et al (2015). The 2018 GHGI estimates 2016 G&B station emissions were 1,968

Gg CH_4 based on the Marchese et al EFs and updated station counts. Alvarez et al estimates 2015 G&B station emissions were 2,100 Gg CH_4 based on a similar approach to the GHGI, but with an updated EF based on a recalculation of Mitchell et al data with a log-normal distribution that accounts for high-emitting facilities above the sampled emission rate.

For the processing segment, the 2018 GHGI uses GHGRP data to estimate 2015 processing plant emissions were 410 Gg CH_4. As discussed in the stakeholder feedback previously submitted by EDF and Colorado State University (CSU) in 2017 to on *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2015: Updates Under Consideration for Natural Gas Systems Processing Segment Emissions*, **we believe this approach underestimates emissions due to methodological issues associated with the GHGRP**. In our feedback, we proposed using an alternative approach that uses facility-level data from Marchese et al and Mitchell et al, which includes site-level measurements from 16 processing plants, to estimate total emissions. GHGRP data could be used to allocate total emissions among sources as a best approximation of source-specific emissions. Alvarez et al estimates 2015 processing plant emissions are 680 Gg CH_4 using an analogous approach with an updated processing plant EF based on a recalculation of Mitchell et al similar to the approach described above for G&B stations.

For the transmission and storage (T&S) segment, the 2018 GHGI estimates 2015 station emissions were 1,100 Gg CH_4 based on partial data from Zimmerle et al (2015), which used component- and site-level measurements from 45 stations measured in Subramanian et al (2015). The 2018 GHGI underestimates T&S emissions by excluding a substantial portion of observed emissions from Zimmerle et al that were classified as super-emitters/uncategorized. This category represents emissions that were quantified by site-level measurements but missing from aggregate component-level measurements due to known issues such as very high emission rate sources that are difficult to quantify at the component level – a phenomenon that was directly observed in these studies. In contrast, Alvarez et al estimates 2015 T&S station emissions were 1,540 Gg CH_4 because it included the 440 Gg from these uncategorized sources.

2. ***Component-level data such as the GHGRP should not be used to estimate total emissions unless emissions are validated with empirical site- and basin-level data***

As discussed in Alvarez et al, emission estimates based on site- and basin-level measurements consistently show that component-based estimates underestimate emissions. While component-based estimates are valuable for understanding the approximate allocation of emissions among sources, they are not suitable for estimating total emissions without the support of other empirical data, because (as discussed above on page 2) component-level studies under-sample abnormal operating conditions which are responsible for a very substantial portion of real emissions. Therefore, relying on component-level GHGRP data to estimate total emissions likely cause the GHGI to underestimate emissions from Natural Gas and Petroleum Systems.

For future years of the GHGI, EPA should improve the accuracy of their emission estimates by incorporating more empirical data including facility- and basin-level. As discussed in the National Academy of Science's report *Improving Characterization of Anthropogenic Methane Emissions in the United States*, verifiability is the key to an accurate, high quality inventory. For example, spatially gridding the GHGI can allow a comparison to basin-level estimates, but the utility of gridding the current GHGI is limited by the spatial resolution of certain GHGI / GHGRP data which aggregates emissions from all facilities owned by an operator in an AAPG basin. To make better use of site-level data, EPA should consider updates to the GHGI and GHGRP when the current format does not allow a straightforward estimate of region-specific, facility EFs. In particular, the GHGRP methodology for the G&B segment would benefit from updates that allow basin-level emissions to be disaggregated to the facility-level. By reorganizing the GHGI and underlying data such as the GHGRP to be verifiable at the site- and basin-level, EPA could use existing and future empirical data to test the accuracy of the inventory. When inaccuracies are discovered, EPA could use empirical data to adjust the GHGI emission estimates and/or focus future efforts on improving methodologies for the sources or regions with the largest discrepancies. A more inclusive use of empirical data from multiple spatial scales will allow EPA to more accurately understand Natural Gas and Petroleum Systems methane emissions.

Thank you for the opportunity to submit feedback on the draft 2019 GHGI. Please feel welcome to contact us if you have any questions.

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References

Allen, D.T., Pacsi, A.P., Sullivan, D.W., Zavala-Araiza, D., Harrison, M., Keen, K., Fraser, M.P., Daniel Hill, A., Sawyer, R.F. and Seinfeld, J.H., 2014. Methane emissions from process equipment at natural gas production sites in the United States: Pneumatic controllers. Environmental science & technology, 49(1), pp.633-640.

Alvarez, R.A., Zavala-Araiza, D., Lyon, D.R., Allen, D.T., Barkley, Z.R., Brandt, A.R., Davis, K.J., Herndon, S.C., Jacob, D.J., Karion, A. and Kort, E.A., 2018. Assessment of methane emissions from the US oil and gas supply chain. *Science*, p.eaar7204.

Lyon, D.R., Alvarez, R.A., Zavala-Araiza, D., Brandt, A.R., Jackson, R.B. and Hamburg, S.P., 2016. Aerial surveys of elevated hydrocarbon emissions from oil and gas production sites. *Environmental science & technology*, 50(9), pp.4877-4886.

Marchese, A.J., Vaughn, T.L., Zimmerle, D.J., Martinez, D.M., Williams, L.L., Robinson, A.L., Mitchell, A.L., Subramanian, R., Tkacik, D.S., Roscioli, J.R. and Herndon, S.C., 2015. Methane emissions from United States natural gas gathering and processing. *Environmental science & technology*, *49*(17), pp.10718-10727.

Mitchell, A.L., Tkacik, D.S., Roscioli, J.R., Herndon, S.C., Yacovitch, T.I., Martinez, D.M., Vaughn, T.L., Williams, L.L., Sullivan, M.R., Floerchinger, C. and Omara, M., 2015. Measurements of methane emissions from natural gas gathering facilities and processing plants: Measurement results. *Environmental science & technology*, *49*(5), pp.3219-3227.

National Academies of Sciences, Engineering, and Medicine. 2018. Improving Characterization of Anthropogenic Methane Emissions in the United States. Washington, DC: The National Academies Press. https://doi.org/10.17226/24987.

Subramanian, R., Williams, L.L., Vaughn, T.L., Zimmerle, D., Roscioli, J.R., Herndon, S.C., Yacovitch, T.I., Floerchinger, C., Tkacik, D.S., Mitchell, A.L. and Sullivan, M.R., 2015. Methane emissions from natural gas compressor stations in the transmission and storage sector: Measurements and comparisons with the EPA greenhouse gas reporting program protocol. Environmental science & technology, 49(5), pp.3252-3261.

Zavala-Araiza, D., Alvarez, R.A., Lyon, D.R., Allen, D.T., Marchese, A.J., Zimmerle, D.J. and Hamburg, S.P., 2017. Super-emitters in natural gas infrastructure are caused by abnormal process conditions. *Nature communications*, *8*, p.14012.

Zimmerle, D.J., Williams, L.L., Vaughn, T.L., Quinn, C., Subramanian, R., Duggan, G.P., Willson, B., Opsomer, J.D., Marchese, A.J., Martinez, D.M. and Robinson, A.L., 2015. Methane emissions from the natural gas transmission and storage system in the United States. *Environmental science & technology*, *49*(15), pp.9374-9383.